Systems Engineering Capstone Marketplace Pilot

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Principal Investigator: Dr. Mark Ardis

Stevens Institute of Technology

Team Members

Missouri University of Science and Technology

Southern Methodist University

Stevens Institute of Technology

University of Alabama in Huntsville

University of Hawaii at Manoa

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BACKGROUND

The goal of this pilot project is to determine the feasibility of and requirements for a systems engineering capstone experience marketplace environment. We hope to increase the number of systems engineering capstone projects conducted at universities each year by facilitating the cooperation and coordination of teams of students from multiple campuses on individual projects. This has the potential for increasing student engagement, as it enables student participation at schools that might not otherwise have the faculty interest or resources to undertake such projects. It also makes it easier to conduct projects of greater size and complexity where the benefits of a systems engineering approach are more visible.

The program is being implemented in three sequential phases over a 12-month period:

During Phase 1/Startup (September 1, 2012-January 31, 2013) the software for the marketplace registry was prepared, candidate projects were entered into the registry, students entered their qualifications into the registry, students volunteered for projects, project teams were created, and projects were started.

During Phase 2/Project Completion (February 1, 2013-June 30, 2013) student projects will complete their work and submit final deliverables to stakeholders, and stakeholders and faculty will perform assessments of student work.

During Phase 3/Guideline Preparation (July 1, 2013-August 31, 2013) all participating faculty will distill the lessons of the distributed team and will prepare guidelines for future instances of the marketplace at a workshop (to be held July 2013), and suggested modifications will be made to the marketplace software.

This section of the report will summarize progress as of February 2013. It is based on first-hand experiences and observations of the principal investigator and a short survey of participating faculty

PARTICIPATING SPONSORS AND PROJECTS

Project ideas and potential sponsors for student projects were found through a combination of search strategies: sponsors and mentors of capstone projects at RT-19 and RT-19A participating institutions, candidate leads suggested by SERC researchers, national laboratory contacts suggested by members of the OASD(R&E) STEM Development Office, and personal networking.

Although there was little time to prepare project proposals, 9 separate projects were collected and presented to student participants through the registry website:

Sponsor	Project
Advertising.com	Mobile advertising effectiveness
FAA	Airport operation and safety
Lincoln Laboratory	Mobile communication system for crisis situations
NASA	*Water vapor radiometer for a satellite
US Army	*Monitoring subsystem for a training system
US Navy	*Safe, affordable ferry for transportation in a developing country
US Navy	*Components for a disaster relief kit
US Navy	Power generator using energy from coastal waves
Videology	Video advertising forecasting capabilities

The projects annotated with leading asterisks were selected by student teams. Two of those projects, the ferry for a developing country and the components for a disaster relief kit, were merged into one project. The monitoring subsystem project is being executed by multiple teams in parallel.

This list was more than adequate to satisfy student needs, as all participating students were able to find projects of interest. Several other project leads were pursued that did not yield proposals in time for the pilot but that may lead to projects in future years.

Participation in this pilot project was limited to schools that had already participated in RT-19 or RT-19A, or were members of the SERC. An invitation to join the pilot was distributed to all of those schools, and several follow-up communications were made to promote interest and participation.

5 schools joined the project:

School	Students
Missouri University of Science and Technology	24 graduate students in systems engineering on 5 separate teams
Southern Methodist University	3 undergraduate students in electrical engineering 4 undergraduate students in computer science
Stevens Institute of Technology	4 undergraduates in engineering management 2 undergraduate students in naval engineering
University of Alabama in Huntsville	4 undergraduates in aerospace engineering
University of Hawaii at Manoa	4 graduate students in information technology

Many potential candidate schools and departments reported that it was already too late to consider participation by the time they were contacted. Nevertheless, the 5 schools that did join provide a variety of institution types and partnership arrangements. Several schools responded with interest in participating in a marketplace system in future years.

EXPERIENCE WITH WEBSITE REGISTRY SYSTEM

The software for the website registry was adapted from a system developed at Stevens Institute by a previous student capstone team. That system was designed to allow students to form multidisciplinary teams through self-selection: students volunteered for proposed projects posted on the website, faculty supervisors reviewed those student applications and approved project participation. There were mechanisms in place for students to post comments on proposed projects and for new projects to be proposed by faculty or students.

Some of the features of the original system were specific to the Stevens environment. For example, in preparing their personal profiles students selected their academic major from a list of majors available at Stevens. This same list was used to allow project proposers to specify types of needed students. Security and access to the website assumed that all users would be members of the Stevens community and would have accounts on the Stevens computing network. All of these features were removed or adapted for use by a wider community.

The resulting system provided facilities to display project proposals and to register students. Instead of a web-based profile entry system students were asked to fill out a form that they uploaded. The principal investigator

had the ability to see all the project choices that students made, but students, faculty and sponsors were only allowed to see the project proposals.

Students used the system to find projects. The project descriptions were short text narratives without any graphics, but with pointers to other websites with more information in some cases. Since students were not able to see whether other students had already selected projects, we did not get a chance to test whether that would have influenced their choices. We also did not test the capability for project sponsors to review and approve student applicants. Instead, faculty at each school reviewed their student applicants.

TEAM FORMATION

Student teams were formed in different ways. At two schools faculty selected projects and assigned students to teams. At two other schools students were allowed to choose their own projects. In all cases faculty were involved in final selection of projects and team members. At Stevens two teams were initially formed to work on independent projects. Faculty then realized that the two teams would work more effectively on a combined project. A team from the University of Alabama in Huntsville also joined the same project.

As mentioned earlier, we were not able to test students' ability to form teams independently through the website registry system. Instead faculty guided or assisted students in the formation of teams. This is an expense (in effort) that we hope to reduce in the future through the marketplace system.

STUDENT TEAM PROGRESS

Each of the student teams made good progress in their first semester. Although almost all of the teams started later than they had originally intended, they have all made up lost time and/or re-scoped their projects to be on schedule. In some cases teams were held up by delays or changes in funding that caused them to rescale their projects. Each of the projects is practicing good systems engineering practices.

STUDENT INTERACTION BETWEEN TEAMS

Some of the student teams had frequent contact with one another, while others did not. The team from the University of Hawaii had originally intended to work with both the SMU team and the MUST team. Neither of those partnerships has developed yet. The Stevens and UAH teams were in constant contact throughout the first semester. They met weekly by Skype and exchanged email regularly.

SUMMARY ASSESSMENT OF STARTUP PHASE

As expected, we were more successful in some areas than in others on this pilot project.

So far the pilot has been successful in:

- finding several good projects and sponsors

- providing a registry website for students to review project proposals and to post their qualifications
- creating an interesting 3-way collaboration on one project

In addition, students made good use of the registry website to find projects.

So far the pilot has been unsuccessful in:

- allowing students to form their own teams through discovery on the website registry
- providing all of the website registry functionality as originally planned
- providing funding to all schools when they needed it
- creating collaborations between teams for all students

Fortunately, all of the student teams are making good progress on interesting projects. Some aspects of their projects, such as interaction with other teams, could be improved, but all projects are good systems engineering experiences for the students.

LESSONS LEARNED AND RECOMMENDATIONS

This section provides recommendations for future efforts in this area. Although we will have more experience on which to report at the end of the pilot, it is worth capturing some of the lessons we have recently learned before they are forgotten.

ENGAGING PARTICIPANTS

Capstone projects are solicited and defined in the spring semester at many schools. Some academic programs try to have all their students assigned to teams before they leave campus for the summer. In some cases projects actually start with student internships that take place during the summer before the senior year. If the marketplace hopes to compete within this environment it must have projects ready for review and selection by April at the latest.

Before making proposals, project sponsors need to consider issues of intellectual property, available resources to support student teams, and scope of potential projects. Examples of past projects, including proposals, intellectual property agreements, project schedules and final presentation materials would be of great help to potential project sponsors. These same artifacts are also an aid to students and faculty in planning and starting new projects. The website registry should have a collection of these artifacts for review and adaptation by other projects.

WEBSITE REGISTRY SYSTEM

We were fortunate to have an existing web-based system that had many of the features we needed for our website registry. Modifying that software was the only feasible strategy we had when the pilot started. However, the software proved to be quite fragile and difficult to modify for our use. It was, after all, only a prototype

constructed by a small team of students. In order to have a trustworthy system to use in the future a new version needs to be created from a fresh start.

Some proposed features of the registry system were not available in the pilot project. For example, students were not able to record comments about projects or potential teammates in the registry. Sponsors were not able to view student applicants to their projects. These features should be implemented and tested in a future version of the registry.

TEAM FORMATION

Although the marketplace concept allows for participation by individual students at different schools it is much easier to engage sub-teams of students, where each sub-team is co-located and supervised by a common faculty member. This fits more easily with existing faculty-student teaching relationships, and it provides more security and robustness in student interactions. Teams of sub-teams also allow for larger projects, which are more realistic examples of multidisciplinary systems engineering.

FUNDING

The marketplace concept allows for multiple types of projects and sponsors. Some sponsors are able to provide funding for student materials and supplies, while others are not. Student teams need to know their budget before starting, and their school contracting offices need to have agreements on hand at the start of the fall term, even though most student teams will not be ready to spend their funds until the spring academic term. It may be easiest at first to work with sponsors who provide their own funding rather than to seek separate funding from government agencies.

CONCLUSION

This pilot project has been successful in creating an initial website registry system for project selection and team formation. Students have begun work on 3 interesting multidisciplinary systems engineering capstone projects. Each team is making good progress and expects to complete their project successfully by the end of the spring term.

The final project report will include feedback from all the students, faculty and sponsors involved in the student projects. In the meantime, some important lessons that have already been learned have been captured. These lessons provide guidance for future efforts in this area.